PB86-202983

Human Body Burden of Mirex in the Southeastern United States

(U.S.) Environmental Protection Agency
Washington, DC

1985

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before comple

1. REPORT NO. EPA/600/J-85/404	2.
	PB86-202983
4. TITLE AND SUBTITLE THE HUMAN BODY BURDEN OF MIREX IN THE SOUTHEASTERN UNITED STATES (Journal Version)	5. REPORT DATE 1985
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) F.W. Kutz, S.C. Strassman, C.R. Stroup, J.C. Carra*, and C.C. Leininger, D.L. Watts, C.M. Sparacino**	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS *Exposure Evaluation Div. (TS-798), Office of Toxic Substances, USEPA, Washington, DC 20460 **Research Triangle Institute, Research Triangle Park, NC 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Environmental Processes & Effects Research Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/600/16

15. SUPPLEMENTARY NOTES

REF: Journal of Toxicology and Environmental Health, 15:385-394, September 1985

16. ABSTRACT Mirex is an organochlorine chemical with pesticidal and other industrial usages. Biologically, mirex was used as an insecticide for the control of imported fire ants in large areas of the southeastern U.S. Evidence of mirex survey exposure in a national survey of chemicals in adipose tissue led to a more intensive survey of the general population in treated counties of the southeastern U.S. A total of 624 adipose tissue speciments were collected from 40 sites selected randomly from 8 southeastern states where mirex was used widescale to combat fire ants. Tissue speciments were analyzed for mirex and selected other organochlorine compounds by electron-capture gas chromatography with confirmation by combined gas chromatography/mass spectrometry. Weighted statistical analysis of the data was conducted to estimate the level of mirex in the study area. It was estimated that 10.2% of the population of southern U.S. had quantifiable levels of mirex in adipose tissue. The estimated geometric mean of the quantifiable residue amounts was 0.286 ppm (lipid basis). Statistical tests of association and regression were used to investigate possible relationships between the presence and levels of mirex, and the Census Division or state of tissue-specimen collection, by age, race and sex. These analyses indicated that region or location of tissue specimen collection (assumed to be area of residence) strongly related to both the presence of mirex residue and the amount of mirex detected. This may be correlated with the amount of mirex applied for fire ant control or with some other exposure patterns in different regions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Mirex Human adipose tissue Dechlorane Human body burden Imported fire ant control		

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 11
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77)

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA/600/J-85/404
JOURNAL ARTICLE

THE HUMAN BODY BURDEN OF MIREX IN THE SOUTHEASTERN UNITED STATES

F. W. Kutz, S. C. Strassman, C. R. Stroup, J. S. Carra

Exposure Evaluation Division (TS-798), Office of Toxic Substances, U. S. Environmental Protection Agency, Washington, D.C.

C. C. Leininger, D. L. Watts, C. M. Sparacino

Research Triangle Institute, Research Triangle Park, North Carolina

Mirex is an organochlorine chemical with pesticidal and other industrial usages. Biologically, mirex was used as an insecticide for the control of imported fire ants in large areas of the southeastern United States. Evidence of mirex exposure in a national survey of chemicals in adipose tissue led to a more intensive survey of the general population in treated counties of the southeastern United States. Forty sites were selected randomly from 8 southeastern states where mirex was used widescale to combat fire ants; a total of 624 adipose tissue specimens were collected from these 40 sites. Tissue specimens were prepared by a modified Mills-Onley-Gather procedure and analyzed for mirex and selected other organochlorine compounds by electron-capture gas chromatography. Positive residue findings were confirmed by combined gas chromatography and mass spectrometry. Weighted statistical analysis of the data was conducted to estimate the level of mirex in the study area. It was estimated that 10.2% of the population of southern United States had quantifiable levels of mirex in adipose tissue. The estimated geometric mean of the quantifiable residue amounts was 0.286 ppm (lipid basis). Statistical tests of association and regression were used to investigate possible relationships between the presence and levels of mirex, and the Census Division or state of tissue-specimen collection, by age, race, and sex. These analyses indicated that region or location of tissue specimen collection (assumed to be area of residence) strongly related to both the presence of mirex residue and the amount of mirex residue detected. This may be correlated with the amount of mirex applied for fire ant control or with some other exposure patterns in different regions.

INTRODUCTION

Mirex is an organochlorine insecticide that was used for imported fire ant control in large areas of the southeastern United States prior to being banned in 1974. Formulated as a bait, mirex was intended to control the imported fire ant (*Solenopsis richteri* Forel and *Solenopsis invicta* Buren). The compound is chemically known as dodecachloro-

This document has been reviewed and approved for publication by the Office of Pesticides and Toxic Substances, U. S. Environmental Protection Agency. The use of trade names or commercial products does not constitute agency endorsement or recommendation for use.

Requests for reprints should be sent to Frederick W. Kutz, Office of Research and Development (RD-682), U. S. Environmental Protection Agency, 401 M Street, SW Washington, D.C. 20460.

NTIS is authorized to reproduce and sell this report. Permission for further reproduction must be obtained from the copyright owner.

Journal of Toxicology and Environmental Health, 15:385-394, 1985
Copyright © 1985 by Hemisphere Publishing Corporation

octahydro-1,3,4-methano-1*H*-cyclobuta[cd]pentalene. Information supplied by the U. S. Department of Agriculture indicates that over 14 million acres in the southern United States were treated at the rate of 0.6 g/acre beginning in 1953.

Mirex is persistent; this characteristic, in combination with the substance's pharmacodynamics, leads to environmental mobility and potential incorporation into various food chains. This chemical is lipophilic and, like certain other chlorinated hydrocarbons, is stored and accumulated in the lipid portion of animal tissues. Like many organochlorines, it stimulates hepatic microsomal oxidative metabolism and causes proliferation of the smooth endoplasmic reticulum of the liver, posing possible hazards as a carcinogen (Doull et al., 1980).

The industrial chemical Dechlorane is structurally identical to mirex. According to the Merck Index (Windholz 1976), it is used as a fire retardant for plastics, rubber, paint, paper, and electrical goods.

Concern about mirex residues found in specimens of human adipose tissue reported by Kutz et al. (1974) led to a special survey focused on the general population of the southeastern United States. Positive detections of mirex in that report were almost exclusively restricted to tissue specimens from the southeastern United States, where fire-ant control presented major problems. From October 1975 through September 1976, samples of human adipose tissue specimens were collected from selected surgical patients and cadavers within a study area defined as all counties having had some federally assisted application of the insecticide mirex between 1965 and 1974, as recorded by the U. S. Department of Agriculture.

The objective of this special environmental study was to determine the prevalence and levels of mirex in human adipose tissue collected from areas that had been treated with this chemical.

Human body burden and other monitoring data are critical factors in an exposure assessment and thus are important contributory elements in quantitative evaluation of hazard and risk. Studies in laboratory animals indicate actual or potential adverse biological activity (toxicity of some description) of a chemical. Monitoring data are used to assess the exposure of selected human and environmental components to the chemical. These two factors combined (adverse biological activity and exposure data) form the cornerstone of risk assessment.

MATERIALS AND METHODS

Sample Design

The target population, or population of inferential interest, was the human population during 1975 to 1976 of all counties in which mirex had been applied, with federal assistance, during the 10-yr period 1965-1975. Collection sites within these eight states were randomly selected and are shown in Fig. 1. Medical examiners or hospital pathologists were con-

FIGURE 1. Adipose-tissue collection sites selected for the mirex special study.

tacted within these sites to collect adipose-tissue specimens following special collection protocols. Selection of hospitals, pathologists, and tissue specimens was deliberate, not random.

There were eight cities in mirex areas where established contacts (hospital pathologists or medical examiners) were already submitting adipose tissue specimens for the existing National Human Adipose Tissue Survey (Kutz et al., 1979). Thirty-two supplementary sites were selected by simple random sampling from a list of all large (population of 50,000 or more) 1974 Ranally Metropolitan Areas (RMAs) in the mirex use area (Rand McNally and Company, 1974). This brought the total number of sites contacted to 40. Within each RMA, hospital-based pathologists and medical examiners were contacted and asked to participate in the study. One hospital per site was inducted into the study.

Subsampling of cadavers and surgical patients within the sampling sites was performed by cooperating pathologists and medical examiners (Lucas et al. 1980); hospitals, pathologists, and medical examiners were selected subjectively. Cadavers and surgical patients were also selected subjectively by the cooperating professionals, who followed guidelines for collecting specimens based on demographic quotas proportional to the population of the particular Census Division. They selected appropriate tissues and screened out individuals from whom tissue specimens would not be obtained. The latter included suspected victims of pesticide or chemical poisoning, institutionalized patients, and cachectic patients.

Specimen quotas based on the demographic (age, race, and sex) distribution for the living population of each Census Division guided the

field contact in submitting specimens from a range of individuals. This was an attempt to ensure adequate representation of these groups in the sample from the hospitalized and cadaver populations actually represented by the sample. The desired proportions of race and sex (but not age) were approximately met on a Census Division level.

Tissue Collection Procedures

Human adipose tissue specimens were obtained from unembalmed cadavers during post-mortem examination or from specimens previously excised during therapeutic or elective surgery. Thus, tissues were received from individuals with pathological conditions as well as those killed by traumatic injury. Tissue collection performed during autopsy was accomplished as quickly as possible after death, and in all instances within 24 h, assuming refrigeration during this interval.

Chemical Analysis

Specimens were analyzed for mirex, using a modified Mills-Onley-Gaither procedure. The adipose tissue was dry-macerated with a sand/-sodium sulfate mixture, and the lipids were isolated by repetitive extractions with pesticide-grade petroleum ether. Pesticide residues were extracted from the lipids with acetonitrile and then partitioned back into petroleum ether by aqueous dilution of the acetonitrile extract. This ether extract was concentrated by Kuderna-Danish evaporation and transferred to a Florisil column for successive ethyl ether/petroleum ether elutions. Both of the respective eluates were concentrated to suitable volumes and the extracts were examined by electron-capture gas chromatography (Mills et al., 1963). The basic analytical methodology used was published in manual form by Thompson (1974).

The method used for determining mirex levels was based on the use of an external standard. Reference standards were injected before, during, and at the end of each mirex specimen group. The standard consisted of a mixture of known amounts of mirex and Aroclor 1260. This mixture not only served purposes of quantitation, but also provided a constant check on the degree of separation between mirex and a late-eluting Aroclor peak. This peak represented an interference found in most tissue specimens due to the ubiquitous nature of certain polychlorobiphenyls. In an effort to maximize the separation of the two peaks, the gas chromatographic procedure was modified, and the analysis was conducted at a temperature slightly below that recommended in the Thompson (1974) pesticides manual. Baseline separation was achieved for mirex and the polychlorobiphenyl peak, and this separation was maintained throughout the analysis period.

Specimens showing positive mirex residues with the electron-capture procedure were further analyzed with combined gas chromatography-mass spectrometry for confirmational purposes. Additionally, the analytical laboratory was required to maintain acceptable

performance levels in an externally moderated interlaboratory quality assurance program. Assessment of these quality-assurance elements demonstrated high reliability of resulting data and has been reviewed by Lucas et al. (1980) and Leininger et al. (1980, 1982).

Statistical Analysis

The data base consisted of 664 observations from 31 responding sites. Forty observations were excluded from analysis: 34 records were of specimens collected outside the reference time period and 6 records showed lipid extractable amounts less than 10% and were deleted as not being adipose tissue. After exclusions, 624 observations were available for the statistical analysis.

In order to use the information to estimate the level of mirex in the general population of individuals living in the target-area RMAs, it was necessary to weight the original values before analysis. This presented some problems because the selection of specimens, which included purposive selection (i.e., not based on a probability framework) at some points, was incompatible with the formation of statistically valid sampling weights. Even assuming that the selection process within sample sites was approximately random, the sample design did not assign equal "probabilities" of selection to all elements (cadavers and surgical patients) in the sample. A method of "quasi" weighting was devised and used for the weighted analyses. The probability of selecting a given RMA was calculated, multiplied by the number of tissue specimens for that RMA, and divided by the 1974 RMA population. The inverse of this selection "probability" was the unadjusted selection weight. Toward compensating for site-level nonresponse, the inverse of the proportion of selected sample sites that responded was multiplied by the unadjusted selection weight for an observation to produce a weight adjusted for nonresponse at the RMA level. This was an attempt to reduce possible nonresponse bias. Again, note that true sampling weights could not be calculated because some stages of selection were not random. Even if all stages involved random selection, an unbiased estimator could not be produced for the living population, because the data from which the estimator was calculated were from surgical patients and cadavers.

The average minimum detectable quantity (using techniques available in 1975-1977) of mirex in human adipose tissue was within the range 0.05-0.10 ppm. About 1% of the target population was estimated to have trace amounts of mirex, for which no specific numerical value was substituted or inserted. Trace quantities were considered positive mirex detections in statistical analyses of presence versus absence of mirex, but were not included in analyses of the quantifiable positive mirex levels. It should be noted that the actual distribution (approximately log normal) of mirex levels contained in human adipose tissues probably consisted of fewer true zeros than the present analytical techniques indicated. The analysis was carried out on the natural log of raw residue amount

divided by the proportion of lipid-extractable material in the specimen. This adjustment was used to account for the variability in the lipid content of a specimen, since the pesticide binds with lipids. Logarithmic transformations are commonly used to normalize the distribution of biological data before statistical analyses.

Sample survey data software was used to estimate means, proportions, and standard errors (Shah, 1979). The statistical approach used for computing the standard errors was a first-order Taylor series variance approximation. A linearized weighted least-squares analysis that incorporated the sampling structure via a Taylorized linearization into the regression model calculations was used for regression analyses (Holt, 1977). The estimated proportions of the target population subgroups with detectable mirex residues were tested for possible significant factor effects by a chi-square test (Fellegi, 1980). The chi-square statistic, while relatively assumption-free, is less sensitive to differences than regression analysis. Regression analysis, by taking more factors into account, requires more assumptions about the underlying structure of the data before it can be considered an appropriate test.

RESULTS AND DISCUSSION

The estimated percent of positive mirex detections and the results of chi-square analyses of positive versus negative detection of mirex in the adipose tissues of the inference population are given in Table 1. The estimated positive mirex detection for the population in the entire eight-state region is 10.2%. Among states, the estimated positive detections range from no mirex residues detected for North Carolina and Texas to 51.1% for Mississippi. The state in which the specimen was collected was the only significant factor for explaining differences in the proportion of the target population that had detectable mirex residues in adipose tissue. Mississippi was the state with a statistically significant larger proportion of positive mirex detection.

Table 2 presents the estimated geometric mean, in ppm, of the level of mirex in the target population who had detectable levels of mirex in their adipose tissue. The overall geometric mean was 0.286 ppm, while within the 8 states the range of geometric means was 0.250 ppm for Georgia to 0.897 ppm for South Carolina. South Carolina was represented by only one specimen with detectable mirex. The next highest geometric mean was Alabama, 0.340 ppm. The *F*-statistics computed to determine differences in geometric means between subgroups of the main factors indicated significant differences for age ($p < 0.05$) and state ($p < 0.001$). This testing did not account for more than one factor at a time; this was done in the regression analysis.

The results for significant regression analyses for the estimated presence or absence of mirex are given in Table 3. A model containing all possible two-way interactions for the four independent variables (age, sex,

TABLE 1. Estimated Percent Positive Detection of Mirex and Chi-Square of Positive/Negative Detection of Mirex Residues

Variable	Estimated percent positive mirex detection (including trace values)	Standard error	Number of sample specimens	χ^2
All	10.2	3.42	624	NA
Age (yr)				
0-14	1.6	1.37	70	2.72
15-44	11.3	3.66	229	
≥45	15.4	3.87	325	
Census Division				
East South Central	37.6	10.94	175	2.6
South Atlantic	13.3	3.06	282	
West South Central	3.6	2.57	167	
Race				
Caucasian	9.8	4.28	471	0.04
Non-Caucasian	11.5	4.02	153	
Sex				
Male	16.1	5.16	298	1.8
Female	6.7	2.79	326	
State				
Alabama	4.6	3.85	39	32[a]
Florida	5.4	1.22	137	
Georgia	19.6	1.87	91	
Louisiana	13.4	9.50	129	
Mississippi	51.1	7.97	136	
North Carolina	0.0	—[b]	18	
South Carolina	3.9	2.66	36	
Texas	0.0	—[b]	38	

[a] Significant at $p \leq 0.001$; no other significant effect less than $p \leq 0.18$.
[b] Insufficient information in sample on which to base estimate.

race, and location of collection site) produced a significant sex versus Census Division interaction relating to percent positive (significance level $p \leq 0.044$). In this interaction, there were no significant differences in the East South Central or West South Central Census Divisions between the proportion of males and females who had detectable mirex residues, but there was a significantly higher proportion of males than females with positive mirex detection in the South Atlantic Census Division. The model in which state was the location factor was limited to a simple main effects model, due to the restrictions imposed by the small number of sites as compared to the sum of factor levels. The significant main effect for state ($p < 0.0001$) in this analysis was similar to the results of the chi-square test, which also showed that there were significantly different proportions of the population with positive mirex residues in different states. Again, Mississippi was the state that had a significantly greater proportion of positive mirex detections than the seven other states. The main effect for sex in this model was marginally significant

TABLE 2. Estimated Mean Levels and Standard Errors of Mirex (ppm)

Variable	Geometric mean (ppm) of mirex, LEM-adjusted positive residues[a] (excluding trace values)	Standard error	Number of sample specimens	*F*-value with 22 denominator degrees of freedom
All	0.286	0.048	123	NA
Age (yr)				
0-14	0.172	0.037	8	3.46
15-44	0.283	0.039	47	($p \leq 0.05$)
≥ 45	0.297	0.077	68	
Census Division				
East South Central	0.292	0.018	61	0.37
South Atlantic	0.266	0.083	23	(NS)
West South Central	0.331	0.049	39	
Race				
Caucasian	0.252	0.030	86	1.88
Non-Caucasian	0.406	0.102	37	(NS)
Sex				
Male	0.322	0.085	65	1.25
Female	0.249	0.023	58	(NS)
State				
Alabama	0.340	—[b]	3	51.45
Florida	0.298	0.105	8	($p \leq 0.001$)
Georgia	0.250	0.085	14	
Louisiana	0.331	0.049	39	
Mississippi	0.290	0.019	58	
North Carolina	—[b]	—[b]	0	
South Carolina	0.897	—[b]	1	
Texas	—[b]	—[b]	0	

[a] LEM, lipid-extractible materials. Calculations within the estimated percent positive.
[b] Insufficient information in sample on which to base estimate.

TABLE 3. Regression Models for Race, Age, Sex, and Collection Site Location: Zero Detectable/Positive Residue Values

Source[a]	Degrees of freedom	*F* value[b]	Pr > *F* significance
Main effects model	6	9.30	0.0001
Census division	2	3.53	0.042
Sex	1	3.03	0.092
Second-order effects model	19	46.41	0.0001
Census division by sex	2	3.45	0.044
Main effects model	11	11.38	0.0001
State	7	16.11	0.0001
Sex	1	2.72	0.109

[a] Only significant factors presented.
[b] Ratios of sampling variances used to test factor effects follow the *F* distribution if the population variances are equal (null hypothesis).

($p < 0.109$). There may have been some interaction between sex and state; however, this could not be tested within this study.

Regression analyses of the estimated levels of quantifiable mirex detections indicated, again, that the location of the collection site was a major factor in the level of mirex detected. Main effects models, involving state and Census Division, respectively, as location factors, did not show any significant effects. A model containing all possible second-order interactions, with Census Division as the location factor, is presented in Table 4. There were marginally significant interactions for Census Division by age group ($p < 0.069$) and for Census Division by race ($p < 0.0106$). This indicated that there have been differences in levels of mirex residue in the adipose tissue among different demographic subgroups of the target population, but that these differences were geographically specific. For example, Caucasians in the East South Central and West South Central Census Divisions had higher levels of mirex residues than did non-Caucasians. In the South Atlantic Census Division, non-Caucasians had higher mirex residue levels than did Caucasians.

A weighted analysis was used in an attempt to identify possible patterns influencing prevalence of mirex residues in the target population. The target population here consisted of all human residents of all counties where mirex was applied during a 10-yr period in 8 southern states.

In the analysis, geographic location of the collection site was the most significant variable of those studied for explaining variation in mirex residues. Some results of the analyses of the entire sample and of the 123 quantifiable observations are listed next.

For the total sample. State was a significant ($p \leq 0.0001$) factor in explaining the variation of positive mirex detection. Mississippi was the

TABLE 4. Regression Model for Census Division of Collection Site, Age, Race, and Sex Versus Quantifiable Positive Mirex Residue Amounts[a]

Source[b]	Degrees of freedom	*F* value[c]	Pr > *F* significance
Second-order effects model[d]	18	129.409	0.0001
Census division	2	Not testable	
Age	2	Not testable	
Race	1	Not testable	
Sex	1	Not testable	
Census division by age	3	2.72	0.0690
Census division by race	2	5.63	0.0106

[a] Dependent variable in model is the $\log_e$ LEM-adjusted mirex residue amount (Leininger et al., 1980).

[b] Only significant factor and interaction effects presented.

[c] Ratios of sampling variances used to test factor effects follow the *F* distribution if the population variances are equal (null hypothesis).

[d] Full higher-order interaction models not estimable.

state studied in which the proportion of mirex residues in human tissues was highest (51.1%).

For the quantifiable residue amounts. There was a significant interaction between geographic location and race. This suggested that there was a possible demographic effect within some geographic divisions that was not particularly strong or consistent throughout the mirex-treated area.

There was less clear-cut evidence of any other large differences in level of residue amount in any particular category studied, although marginally statistically significant results were found for several categories.

It must be emphasized that the limitations of the sample selection methodology affected the interpretation of results. Residue levels and other pertinent population values could not be accurately estimated with any assurance unless the probabilities with which a given tissue specimen was chosen could be calculated. These findings could be interpreted only as indications of trends or patterns which may have existed in the population living in the mirex treated region. This requires assuming that the group of cadavers and surgical patients was representative of the corresponding groups in the general population.

REFERENCES

Doull, J., Klaassen, C. D., and Amdur, M. O., eds. 1980. *Casarett and Doull's Toxicology*, 2d ed., pp. 387-389. New York: Macmillan.

Fellegi, J. P. 1980. Approximate tests of independence and goodness of fit based on stratified multistage samples. *J. Am. Stat. Assoc.* 75(370):261-268.

Holt, M. M. 1977. SURREGR: Standard errors of regression coefficients from sample survey data. Research Triangle Park, N.C.: Research Triangle Institute.

Kutz, F. W., Yobs, A. R., Johnson, W. G., and Wiersma, G. B. 1974. Mirex residues in human adipose tissue. *Environ. Entomol.* 3:882-884.

Kutz, F. W., Strassman, S. C., and Sperling, J. F. 1979. Survey of selected organochlorine pesticides in the general population of the United States: Fiscal years 170-1975. *Ann. N. Y. Acad. Sci.* 320:60-68.

Leininger, C. C., Watts, D. L., Sparacino, C., and Williams, S. 1980. Mirex residue levels in human adipose tissue: A statistical evaluation. Washington, D.C.: U. S. Environmental Protection Agency EPA 560/13-80-024.

Leininger, C. C., Watts, D. L., Sparacino, C. M., Stroup, C. R., Strassman-Sundy, S. C., and Kutz, F. W. 1982. Final report: A study of mirex residues in human adipose tissue. RTI/1864/17-02F. Washington, D.C.: U. S. Environmental Protection Agency Contract 68-01-5848.

Lucas, R. M., Rosenzewig, M. S., and Williams, S. R. 1980. Evaluation of and alternate designs for National Human Monitoring Program's Adipose Tissue Survey. RTI/1864/14/02-02I. Washington, D.C.: Office of Toxic Substances, U. S. Environmental Protection Agency Contract 68-01-5848.

Mills, P. A., Onley, J. H., and Gaither, R. A. 1963. Rapid method for chlorinated pesticide residues in non-fatty foods. *J. Assoc. Offic. Anal. Chem.* 46:186-191.

Rand McNally and Co. 1974. *Commercial Atlas and Marketing Guide*. New York: Rand McNally.

Shah, B. V. 1979. SESUDAAN: Standard errors program for computing of standardized rates from sample survey data. Research Triangle Park, N.C.: Research Triangle Institute. RTI/1789/00-01F.

Thompson, J. F., ed. 1974. Analysis of pesticide residues in human and environmental samples. Research Triangle Park, N.C.: U. S. Environmental Protection Agency.

Windholz, M., ed. 1976. *The Merck Index*, 9th ed. p. 324. Rahway, N.J.: Merck.

Received July 27, 1984
Accepted December 3, 1984